Neue Versuchungen an den Ohrenbogengängen. J. BREUER. Pflüger's Archiv, Bd. XLIV, p. 135, 1888.

Any doubt which may have remained among physiologists as to the effect of the semicircular canals upon the sense of direction must be completely set at rest by these admirable experiments of Breuer. The one thing which remained to be done—the separate excitation of the three canals by the electric current, and the production of the corresponding motions of the head under circumstances which excluded the possibility of any accompanying injury to the brain—has now been successfully accomplished. These experiments are, of course, very much superior in delicacy and conclusiveness to those in which the semicircular canals are cut. As little as possible of the ampullae is exposed, and the dove is kept in a state of stupor sufficient to prevent spontaneous motions. The strongest reactions—motions of the head through an angle of forty-five degrees—are got by the application of heat and cold. As Breuer showed in a former paper (1875), the motion, in the plane of a given canal, is in a different direction according as one end or the other of its ampulla is excited. When the electric current is used, the direction of motion changes with the direction of the current, and with the intermittent current no motion at all is obtained. The head of the dove may thus be made to move at pleasure in any one of six different ways, two in each of the three planes of the semicircular canals. That the current does not act directly upon the brain is proved in the following way: the point of the gold-tipped needle which forms the cathode is first inserted into the brain near the ear, and then the strength of the current is diminished until motion is no longer obtained in this way. The needle is then applied to the canals, and the same strength of current is here found to be sufficient to produce a marked reaction. It is not, of course, shown that the cerebellum is not concerned in the motion, but that the canals are the peripheral sense-organ for the centers in the cerebellum. Breuer's former experiments in mechanical stimulation of the canals he has repeated and confirmed. Motion of the head can be made to take place in one direction or the other according to the end of the canal from which the endolymph is sucked out by a scrap of blotting-paper; the direction of the motion is the same as that of the endolymph-stream.

It would seem that a more important rôle ought to be attributed to the semicircular canals in the derivation of the space-feeling than is usually done. It may also be conjectured that a fourth dimension in space will remain forever inconceivable to us until after we have developed a fourth semicircular canal. C. L. F.

Die Abhängigkeit zwischen Reiz und Empfindung. Dr. JULIUS MERKEL. Philosophische Studien, IV, 4, pp. 541–596, and V, 2, pp. 245–292.

This elaborate paper recounts, with a mass of unnecessary details and a bewildering abundance of confusing tables, a series of experiments designed with great care, carried out with infinite patience, and directed to the solution of the most important problem of psychophysics. It would be impossible to notice here all the many points touched upon in this comprehensive study; only the conclusions reached, the methods used, and the inferences drawn from the results can be summarized. Ordinary observation would call

attention to the fact that sensation increases more slowly than stimulation; double as large a chorus does not give double the effect, and so on. But what the ratio between the two is remains to be determined. The logarithmic ratio is only one of a number. Moreover, the results by one method will not be directly translatable into another. Only by the agreement of several methods applied to the same problem can a conclusive result be reached. The main issue will be between the hypothesis claiming the distinctions between sensations to depend upon relative increments of stimulus, and that claiming that they depend upon absolute increments. The methods that Merkel employs are those of the just observable difference, the method of doubles, and the method of mean gradations. The first is used in a novel and improved form. It consists in asking the subject to adjust a stimulus so as to give a just appreciably greater sensory effect than a given stimulus; in other words, to record the difference at which a confidence nearing certainty is reached. The method of doubles consists in setting one stimulus so as to give a sensation twice as intense as a given sensation. The inference from the method is, that according to the one hypothesis the stimulus should be more than double, while according to the other it ought to be approximately correct. The third is a well-known one of Wundt's, and consists in adjusting a stimulus to give a sensation midway in intensity between a given pair of sensations. The argument is that if the "absolute" hypothesis holds the result would be the geometrical mean, while if the "relativity" hypothesis holds it would be the arithmetical mean. The two senses experimented upon were the sense of visual brightness and that of pressure with an admixture of the muscle-sense. For the former, three parallel dark chambers, each containing a lamp, were so arranged as to illuminate three disks with light of variable intensities. The adjustment was made by moving the lamps toward or away from the observer, and many precautions were taken to insure accuracy in the comparisons. The effect of contrast between the disks is the most disturbing factor in the experiments, and is compensated more or less completely by various devices. Calling the weakest illumination the apparatus could give 1, the range was from 1 to 4096.

The chief results are the following: (1) The method of the just observable difference shows Weber's law to be not valid between light intensities .5 to 64 (the sensibility increasing with the stimulus), but from 64 to 4096 the law is approximately correct; (2) the method of doubles shows that a stimulus is regarded as the double of another before it is really double, and this probably as the result of contrast; (3) the method of mean gradations shows a result much nearer the arithmetical than the geometrical mean; (4) the inference is that if two stimuli are to be distinguishable, the resulting sensations must bear a constant *ratio* to one another; (5) accepting this last hypothesis, one may say that if the stimulus .5 be regarded as completely converted into sensation, only .17 to .3 of the stimuli 64 to 4096 can be regarded as thus converted; (6) if the effect of contrast be eliminated in the method of doubles and of mean gradations, the results are in harmony with those of the just observable difference under the acceptance of the "relativity" hypothesis.

The pressure apparatus consisted, in essence, of a beam with a weight variable in size and in its position on the beam; the short end of the beam was provided with a cap upon which the finger

pressed down, thus supporting the weight attached to the other end. This downward pressure is evidently a muscular effort, even though the movement was only a few millimeters; and the resulting values seem to indicate a greater sensibility than the pure pressure-sense would give. By having three such beams, all three of the methods used with visual impressions could be applied to this kind of touch sensations. The pressures were varied from 1 gramme to 2000 grammes. The results expressed, as those with sensations of brightness, are as follows: (1) The sensibility increases as the stimulus increases up to about 200 grammes, and from there to 2000 grammes is quite constant. (2) The sensibility is finer (*a*) with successive than with simultaneous impressions; (*b*) when muscular sensibility is added to pressure sensations, than without the latter; (*c*) when the same finger is used for the various sensations than when different fingers are used; (*d*) when the surface in contact is small than when it is large—these points holding for all the methods of experimentation as well. (3) In the method of doubles, the ratios assigned as the double decrease as the stimuli increase. (4) By the method of mean gradations, the adjustments are much nearer the arithmetical than the geometrical mean. (5) On the basis of the relativity hypothesis, and assuming that with the sensation of 1 gramme all the stimulus is converted into sensation, then from 200 to 2000 grammes only .114 to .163 of it is thus converted; and a not very different result is obtainable from the other two methods when the effects of contrast are eliminated.

This research is thus in opposition to several of the accepted generalizations of psychophysics, and though some of this antagonism is more apparent than real, it will be a most delicate and difficult work to bring unity and harmony into this most perplexing field of experimental psychology. J. J.

Ueber den Rhythmus centraler Reize. Dr. R. v. LIMBECK. Archiv für experimentelle Pathologie, Bd. XXV, H. 2.

The author has reopened the question of the rhythm of muscular contractions following central stimulation. Using induction shocks and recording the results graphically, he stimulated the cortex in dogs and rabbits and the cord in rabbits and frogs directly, and the cord in frogs, toads, rabbits and doves reflexly, stimulating the N. ischiadicus on one side so as to cause contractions on the other. In contradiction to the hitherto accepted view, he found that the central system did not send out motor impulses at a fixed rate, no matter how fast stimuli were sent into it, but that, within the limits of experiment, as many impulses were sent out as were received. His rates were for the cortex 6½–13 per sec., for the cord 5½–34, and for the same by reflex stimulation 4½–19½. Faster rates, when applied, gave smooth curves. Tracings of the spontaneous tetanus of strychnine poisoning showed a variable rate of central discharge.

Ein photometrischer Apparat zu psychophysischen Zwecken. A. KIRSCHMANN. Philosophische Studien, V, 2, 1888, pp. 292–301.

Owing to the difficulties in the accurate observation of differences of sensations of brightness, such as contrast, differences in sensibility of neighboring parts of the retina, variations in accommoda-